CLAIMS

1. A photomask comprising:

    a mask pattern formed on a transparent substrate; and

    a transparent portion of said transparent substrate where said mask pattern is not

5   formed,

    wherein said mask pattern includes a first pattern and a second pattern each

    having a mask enhancer structure including a phase shifter for transmitting exposing light

    in an opposite phase with respect to said transparent portion and a shielding portion

    surrounding said phase shifter,

10 said first pattern is close to a third pattern included in said mask pattern at a

    distance not larger than a given distance with said transparent portion sandwiched

    therebetween, and

    a width of said phase shifter of the mask enhancer structure of said first pattern is

    smaller than a width of said phase shifter of the mask enhancer structure of said second

15 pattern.

    2. The photomask of Claim 1,

    wherein each of regions of said transparent portion disposed on both sides of said

    second pattern has a width larger than a given dimension.

    3. The photomask of Claim 2,

20 wherein said third pattern has the mask enhancer structure or is made of a

    shielding portion.

    4. The photomask of Claim 3,

    wherein said third pattern is provided with a semi-shielding portion for partially

    transmitting the exposing light in an identical phase with respect to said transparent portion

25 instead of said shielding portion of the mask enhancer structure.

5. The photomask of Claim 1,

wherein said second pattern is close to a fourth pattern included in said mask pattern at a distance not larger than said given distance with said transparent portion sandwiched therebetween, and

5   the distance between said second pattern and said fourth pattern is larger than the distance between said first pattern and said third pattern.

6. The photomask of Claim 5,

wherein each of said third pattern and said fourth pattern has the mask enhancer structure or is made of a shielding portion.

10   7. The photomask of Claim 6,

wherein each of said third pattern and said fourth pattern is provided with a semi-shielding portion for partially transmitting the exposing light in an identical phase with respect to said transparent portion instead of said shielding portion of the mask enhancer structure.

15   8. The photomask of Claim 1,

wherein said second pattern is close to a fifth pattern included in said mask pattern at a distance equivalent to the distance between said first pattern and said third pattern with said transparent portion sandwiched therebetween,

said third pattern has the mask enhancer structure, and

20   said fifth pattern is made of a shielding portion.

9. The photomask of Claim 8,

wherein said third pattern is provided with a semi-shielding portion for partially transmitting the exposing light in an identical phase with respect to said transparent portion instead of said shielding portion of the mask enhancer structure.

25   10. The photomask of Claim 1,

wherein said first pattern and said second pattern are connected to each other, thereby forming one continuous pattern.

11.   The photomask of Claim 1,

wherein said given distance is not larger than (λ/NA) x M, wherein λ indicates a

5   wavelength of the exposing light and M and NA respectively indicate a reduction ratio and numerical aperture of a reduction projection optical system of a projection aligner.

12.   The photomask of Claim 1,

wherein each of said first pattern and said second pattern has a width not larger than (0.8 x λ/NA) x M, wherein λ indicates a wavelength of the exposing light and M and

10   NA respectively indicate a reduction ratio and numerical aperture of a reduction projection optical system of a projection aligner.

13.   The photomask of Claim 12,

wherein a difference in the width between said first pattern and said second pattern is not larger than (0.2 x λ/NA) x M.

15   14.   The photomask of Claim 13,

wherein a ratio of the width of said phase shifter of the mask enhancer structure of said first pattern to the width of said first pattern is smaller than a ratio of the width of said phase shifter of the mask enhancer structure of said second pattern to the width of said second pattern.

20   15.   The photomask of Claim 1,

wherein each of said first pattern and said second pattern is provided with a semi-shielding portion for partially transmitting the exposing light in an identical phase with respect to said transparent portion instead of said shielding portion of the mask enhancer structure.

25   16.   The photomask of Claim 15,

wherein said semi-shielding portion transmits the exposing light with a phase difference not less than (-30 + 360 x n) degrees and not more than (30 + 360 x n) degrees (wherein n is an integer) with respect to said transparent portion.

17. The photomask of Claim 15,

5   wherein said semi-shielding portion is made of a metal thin film with a thickness of 30 nm or less.

18. The photomask of Claim 1,

wherein said phase shifter of the mask enhancer structure of each of said first pattern and said second pattern transmits the exposing light with a phase difference not less

10   than (150 + 360 x n) degrees and not more than (210 + 360 x n) degrees (wherein n is an integer) with respect to said transparent portion.

19. The photomask of Claim 1,

wherein said phase shifter of the mask enhancer structure of each of said first pattern and said second pattern is formed by trenching said transparent substrate.

15   20. A photomask comprising:

a mask pattern formed on a transparent substrate; and

a transparent portion of said transparent substrate where said mask pattern is not formed,

wherein said mask pattern includes a first pattern having a mask enhancer

20   structure including a phase shifter for transmitting exposing light in an opposite phase with respect to said transparent portion and a shielding portion surrounding said phase shifter and a second pattern adjacent to said first pattern with said transparent portion sandwiched therebetween, and

a width of said phase shifter of the mask enhancer structure of said first pattern is

25   set to be smaller as a distance between said first pattern and said second pattern is smaller.

21.   A photomask comprising:

a mask pattern formed on a transparent substrate; and

a transparent portion of said transparent substrate where said mask pattern is not formed,

5   wherein said mask pattern includes a first pattern having a mask enhancer structure including a phase shifter for transmitting exposing light in an opposite phase with respect to said transparent portion and a shielding portion surrounding said phase shifter and a second pattern adjacent to said first pattern with said transparent portion sandwiched therebetween, and

10   a width of said phase shifter of the mask enhancer structure of said first pattern is set to be smaller when said second pattern has the mask enhancer structure than when said second pattern is made of a shielding portion.

22.   A pattern formation method using the photomask of Claim 1, comprising the steps of:

15   forming a resist film on a substrate;

irradiating said resist film with the exposing light through said photomask; and

forming a resist pattern by developing said resist film having been irradiated with the exposing light.

23.   The pattern formation method of Claim 22,

20   wherein oblique incident illumination is employed in the step of irradiating said resist film with the exposing light.

24.   A mask data generation method for a photomask including a mask pattern formed on a transparent substrate and a transparent portion of said transparent substrate where said mask pattern is not formed, comprising the steps of:

25   generating a pattern corresponding to a desired unexposed region of a resist

formed by irradiating said resist with exposing light through said photomask;

determining a shape of a phase shifter disposed within said pattern for transmitting the exposing light in an opposite phase with respect to said transparent portion;

5   adjusting a width of said phase shifter on the basis of a distance from said pattern to a different pattern close to said pattern with said transparent portion sandwiched therebetween;

setting an edge of said pattern corresponding to a boundary with said transparent portion as a CD adjustment edge;

10   predicting a dimension of a resist pattern formed by using said pattern including said phase shifter through simulation; and

when said predicted dimension of said resist pattern does not accord with a desired dimension, deforming said pattern by moving said CD adjustment edge.

25.   The mask data generation method of Claim 24,

15   wherein said pattern includes a semi-shielding portion for transmitting the exposing light in an identical phase with respect to said transparent portion.

26.   The mask data generation method of Claim 24,

wherein the step of determining a shape of a phase shifter includes the sub-steps of:

20   setting at least two or more different widths as a width of said phase shifter; and

setting the width of said phase shifter to be larger when said pattern has a small width not larger than a given width than when said pattern has a width larger than said given width.

25   27.   The mask data generation method of Claim 24,

wherein the step of adjusting a width of said phase shifter includes the sub-steps of:

setting at least two or more different widths as the width of said phase shifter; and

5   setting the width of said phase shifter to be smaller when the distance between said pattern and said different pattern is not larger than a given dimension than when the distance between said pattern and said different pattern is larger than said given dimension.

28.   The mask data generation method of Claim 24,

10   wherein the step of adjusting a width of said phase shifter includes the sub-steps of:

setting at least two or more different widths as the width of said phase shifter; and

setting the width of said phase shifter to be smaller when said pattern is

15   close to said different pattern at a distance not larger than a given dimension and said different pattern includes a different phase shifter than when said pattern is close to said different pattern at a distance not larger than said given dimension and said different pattern does not include a different phase shifter.

29.   The mask data generation method of Claim 24,

20   wherein said different pattern includes two patterns close to respective sides of said pattern, and

the step of adjusting a width of said phase shifter includes sub-steps of:

setting at least two or more different widths as the width of said phase shifter;

25   obtaining distances S1 and S2 respectively from said two patterns close

to the respective sides of said pattern to said pattern; and

setting the width of said phase shifter to be smaller when (S1 + S2)/2 is not larger than a given value than when (S1 + S2)/2 is larger than said given value.